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Taxonomic Reassessment and Conservation Status of Three Kaua'i Species of *Asplenium* in the *Diellia* Alliance

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Abstract.—Morphological variation of three Kaua'i species of *Asplenium* in the *Diellia* alliance is evaluated based on recent field observations and herbarium specimens. Their taxonomy, nomenclature, and synonymy are discussed, and a lectotype is selected for *Lindsaya knudsenii*. *Asplenium diellaciniatum* is interpreted as having extremely variable frond morphology and dissection, whereas *A. dielmannii* and *A. dielpallidum* are morphologically much more uniform. Their conservation status and population sizes are reviewed.

Key Words.—Aspleniaceae, *lectotypification*, *morphology*, Kaua'i, Hawai'i, conservation, taxonomy

The Hawaiian endemic fern genus *Diellia* Brack. was previously considered to include six species (Palmer 2003; Wagner 1952, 1993). The origin of this group of six species is thought to date to ca. 2 Myr ago and coincide with the renewal of Hawaiian terrestrial life in the Miocene (Schneider et al. 2005a). However, recent molecular phylogenetic studies have shown *Diellia* to be deeply nested within *Asplenium* L. (Schneider et al. 2005b), and all names in *Diellia* have been transferred to or given new names in *Asplenium* (Viane & Reichstein 1991; Snow 2011; Snow et al. 2011). However, the new names or combinations were made by these authors essentially to provide valid names for these taxa in *Asplenium* based on Palmer's and Wagner's species concepts, without any further taxonomic evaluation. Consequently, several of the species complexes in this group have not yet been satisfactorily resolved taxonomically, including one with three species on Kaua'i. Recent intensive field work on Kaua'i by the second and third authors has revealed the presence of new populations of taxa in this rare *Asplenium* alliance. Observations and specimens deposited in the National Tropical Botanical Garden Herbarium (PTBG) have helped reassess the considerable morphological variation in this complex. We here discuss the taxonomy, nomenclature, and synonymy of the three Kaua'i species in this alliance and select a lectotype for *Lindsaya knudsenii*.

As currently circumscribed, three species in this alliance occur on Kaua'i, separable by characters in the key below. They are: *Asplenium dielmannii*

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Viane, *A. dielpallidum* Viane, and *A. diellaciniatum* Viane. The first two species are relatively uniform morphologically and easily recognized. However, population studies of the third species reveal an amazing range of variation in leaf morphology and degree of lobing. Hillebrand (1888) named four different species and six varieties (not all were validly published) in the genus *Lindsaya* Kaulf. [= *Lindsaea* Sm.] in order to encompass this astonishing array of variation: *Lindsaya alexandri* (Hillebr.) Hillebr. including one variety from Kaua'i, var. *bipinnata* Hillebr. (fronds bipinnate); *Lindsaea centifolia* Hillebr. from Kaua'i; *Lindsaea knudsenii* Hillebr. from Kaua'i; and *Lindsaea laciniata* Hillebr. from Kaua'i, with var. subpinnata (fronds subpinnate).

Except for the two varieties of *Lindsaya alexandri* from Maui, all the specimens Hillebrand used to typify these names were collected from essentially the same vicinity on Kaua'i, called "Halemanu" by island resident Valdemar Knudsen who sent plant specimens to Hillebrand. The specimens were subsequently deposited in the Berlin herbarium and images are now available online (Röpert 2000-present, http://www.bgbm.org/). Halemanu was the site of the Knudsen family's mountain home in western Kaua'i. Searches in the vicinity of the old Knudsen homestead have failed to reveal any extant populations of *Asplenium diellaciniatum* around Halemanu (K. Wood, pers. obs.) However, two new populations numbering ca. 90 plants were recently discovered at Kawai'iki, located about 7.25 km from Halemanu in a similar habitat type, *Acacia koa* A. Gray mesic forest.

Study of these two subpopulations at Kawai'iki and additional herbarium collections reveals that these morphotypes are neither consistent nor stable and intergrade with each other. We conclude that a single species, *Asplenium diellaciniatum,* is represented with extremely variable frond morphology and dissection, depending on age and stage of development of the plant and possibly also microhabitat (K. Wood and R. Aguraiuja, pers. obs.). A single plant may even possess fronds representing several morphotypes corresponding to taxa described by Hillebrand (e.g., *Wood & Query 1174, 1175, 1177,* all PTBG; *Wood & Perlman 9015, 9060, 9062, 9062B, 9062C,* all PTBG), (Figures 1, 2). A similar situation exists in *A. daucifolium* Lam., a species of Madagascar and the Mascarene Islands which displays a series intergrading frond forms ranging from 1- to 4-pinnate (Tardieu-Blot 2008).

In his seminal study of the morphology and taxonomy of the genus *Diellia,* Wagner (1952) recognized this variation for Kaua'i plants but ascribed it to *Diellia erecta* Brack., as forma *alexandri* (Hillebr.) W. H. Wagner. He recognized two additional species from this region of Kaua'i, *D. mannii* (D.C. Eaton) W. J. Rob. and *D. laciniata* (Hillebr.) Diels, and later described a third species, *D. pallida* W. H. Wagner (1993). Wagner's species concepts were generally followed by Palmer (2003) in his treatment of Hawaiian ferns. Palmer recognized *Diellia pallida* and *D. mannii* [=*Asplenium dielmannii* Viane] as distinct species, although he synonymized Hillebrand's *Lindsaya knudsenii* β var. under the latter. He also subsumed the names *Diellia centifolia* and

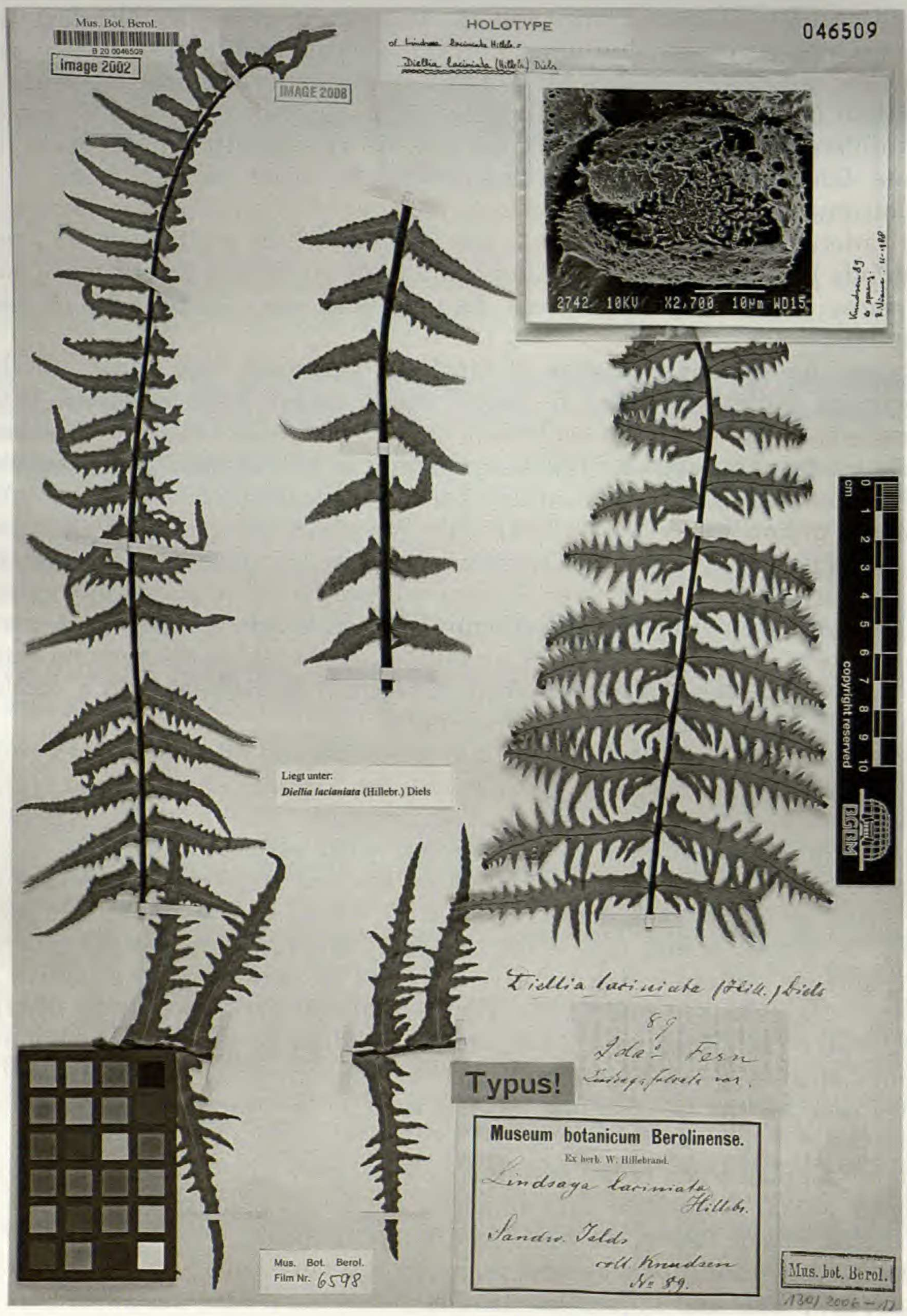

FIG. 1. *Asplenium diellaciniatum*. Holotype of *Lindsaya laciniata* Hillebr. (Knudsen 89, B), courtesy of Röpert, D. (Ed): Digital specimen image at the Herbarium Berolinense. - Published on the Internet http://ww2.bgbm.org/herbarium/ (Barcode: B 20 0046509 / ImageId: 268009) [accessed 29-May-13].

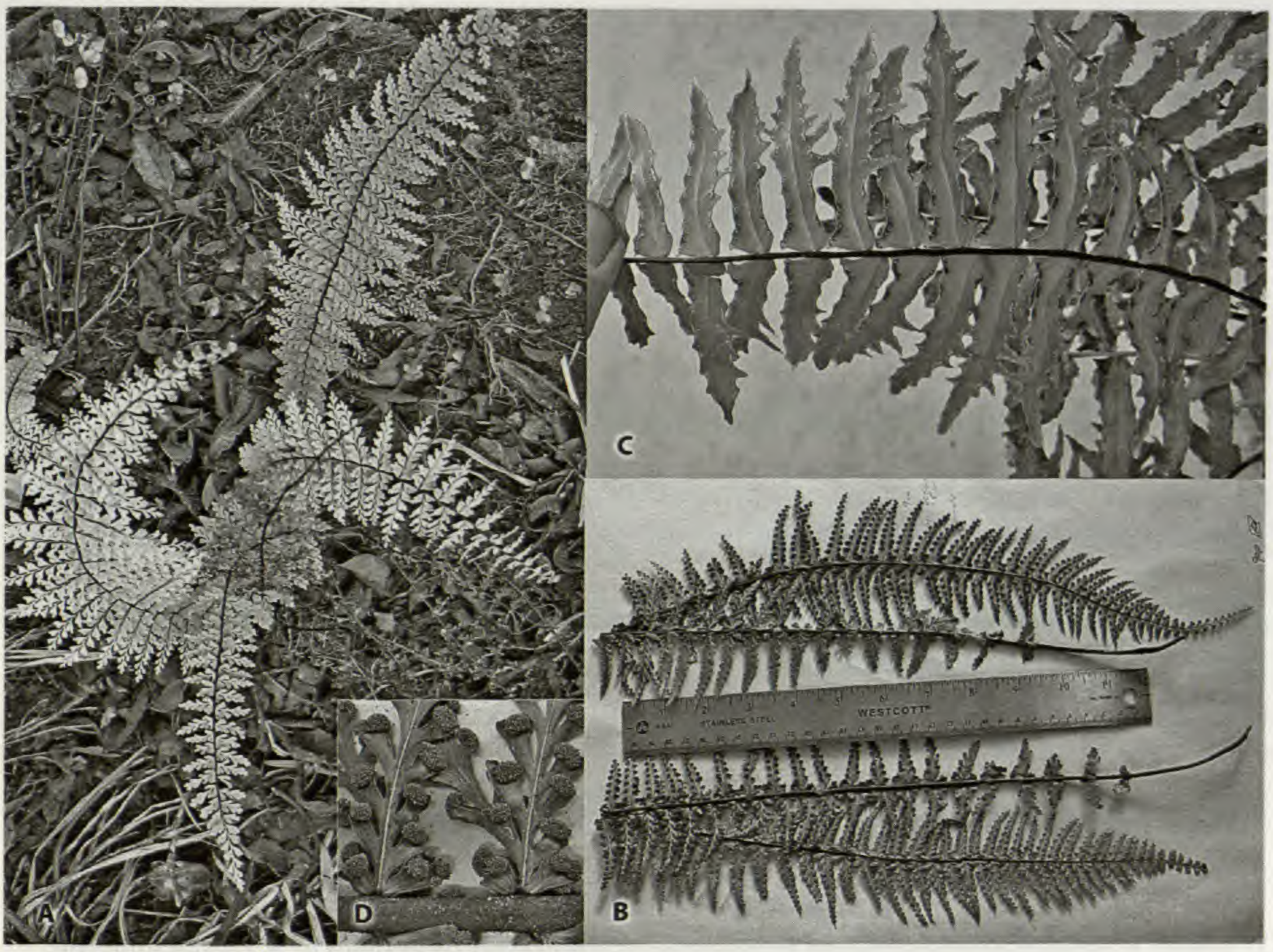

FIG. 2. *Asplenium diellaciniatum.* A, habit, bipinnate-pinnatifid form, Kawai'iki, Kauai'i; B, D, pinnate-pinnatifid form, Kawai'iki, Kaua'i; C, irregularly laciniate pinnate-pinnatifid form, Kawai'iki, Kauai'i. (Photos: A, Ruth Aguraiuja, unvouchered; B, D, *K. R. Wood 9010* (PTBG); C, *D. Lorence 10189,* PTBG, from cultivated plant NTBG # 100358, origin Kawai'iki, Kauai'i.)

Hillebrand's varieties γ and δ of *Lindsaya alexandri* under *Diellia erecta* Brack f. *alexandri* (Hillebr.) W. H. Wagner.

The name *Diellia erecta* Brack f. *alexandri* has been incorrectly applied to Kaua'i plants. Hillebrand's two syntypes of *Diellia alexandri* are from East Maui and Kaua'i and resemble each other superficially, which apparently has given rise to the belief that a single widespread species is involved. In our opinion, however, the two syntypes actually represent two distinct taxa. The Kaua'i syntype (*Knudsen s.n.*, B) is referable to *Asplenium diellaciniatum,* whereas the Maui syntype (*Lydgate & Alexander s.n.*, B) is referable to *A. dielerectum.* Furthermore, the type of *D. erecta* Brack. is from East Maui, suggesting this species is restricted to Maui Nui (Maui, Lana'i, and Moloka'i), an opinion shared by Hillebrand (1888). Wagner (1952: 156) effectively lectotypified *D. erecta* f. *alexandri* [based on *Lindsaya alexandri* Hillebr.] by citing *Lydgate s.n.* from the North flank of Haleakala as "type", thus effectively linking this name to a plant from Maui. Wagner nevertheless believed *D. erecta* f. *alexandri* occurred on Kaua'i as well as Maui, Lana'i, and Moloka'i, noting that the Maui Nui plants have fronds that are also variable in dissection and intergrade, similar to the variability expressed in the Kaua'i plants. The Kaua'i

plants, however, are generally larger with fronds 50–70 cm long and robust stipes 2.5–3.5 mm thick, compared with the Maui Nui plants, which have shorter fronds and thinner stipes 1–2 mm thick. Wagner (1952) separated Kaua'i populations of *D. erecta* from those on the other islands based on their maroon or darker stipes with large gray or tan scales, fronds with 20–40 pinna pairs, the blade apex narrowing abruptly, and the cuneate segments narrow at the base.

Since Wagner linked the epithet *alexandri* to the Maui plants, which we consider to represent a distinct species (*Asplenium dielerectum*), we conclude the name *A. diellaciniatum* Viane [syn. *Diellia laciniata* (Hillebr.) Diels] should be applied to the Kaua'i plants for two reasons. First, the holotype (Fig. 1) is from Kaua'i and corresponds closely to morphotypes in the Kawai'iki population displaying laciniate-pinnatifid lobing of the pinnae. Secondly, although *Lindsaya knudsenii* and *L. laciniata* were published concurrently by Hillebrand (1888), the name *Asplenium diellaciniatum* Viane [based on *Lindsaya laciniata* Hillebr.] is available in *Asplenium* and must be adopted under the International Code of Botanical Nomenclature (McNeill et al., 2012). The three species in the *Diellia* alliance occurring on Kaua'i may be separated by the following key. Nomenclature and synonymy are given below for each species.

Key to Kaua'i *Asplenium* in the *Diellia* Alliance (Adapted from Palmer 2003)

1. Blades 3-pinnate to 3-pinnatifid or 4-pinnate; ultimate pinnule segments narrow, linear or linear-lanceolate, 0.4–1.4 mm wide, thinly chartaceous. . . . . *A. dielmannii*
1. Blades 1- to 2-pinnate (sometimes 3-pinnatifid or completely 3–pinnate in *A. diellaciniatum*); pinnae entire to serrate or laciniate, or ultimate segments usually cuneate if present, 1.5–3(5) mm wide, texture stiffly chartaceous or subcoriaceous. 2
   2. Stipes and rachis usually light to dark brown or pale tan, dull; blades 1-pinnate; pinnae entire; veins usually anastomosing to form 2–3 layers of areoles close to costae near bases of pinnae. . . . . *A. dielpallidum*
   2. Stipes and rachis black or purple-black to maroon, shiny; blades 1–2(3)-pinnate, pinnae entire to shallowly or deeply pinnatifid or pinnate; veins mostly free, seldom anastomosing near costae to form one layer of areoles. . . . . *A. diellacinatum*

1. ***Asplenium diellaciniatum*** Viane, Biol. Jaarb. 59: 159. 1991, nom. nov. for *Lindsaya laciniata* Hillebr., Fl. Hawaiian Isl. 621. 1888, not *Asplenium laciniantum* D. Don. (1825). Type: USA, Hawaiian Islands, Kaua'i, s. loc., "Ida's Fern, Lindsaya falcata var.", *Knudsen 89* (Holotype B-20 0046509, image seen; fragment NY [pinna], image seen).

Lindsaya knudsenii Hillebr., Fl. Hawaiian Isl. 623. 1888. Type: USA, Hawaiian Islands, Kaua'i, Halemanu, Knudsen [as "Kn"] 22 (**lectotype, here designated**: B-20 0046502, image seen; Isolectotype: Knudsen 22, B-20 0046505).

Lindsaya centifolia Hillebr. Fl. Hawaiian Isl. 621. 1888. Type: USA, Hawaiian Islands, Kaua'i, Halemanu, without precise date, Knudsen s.n. [as "Kn"] (Not located).

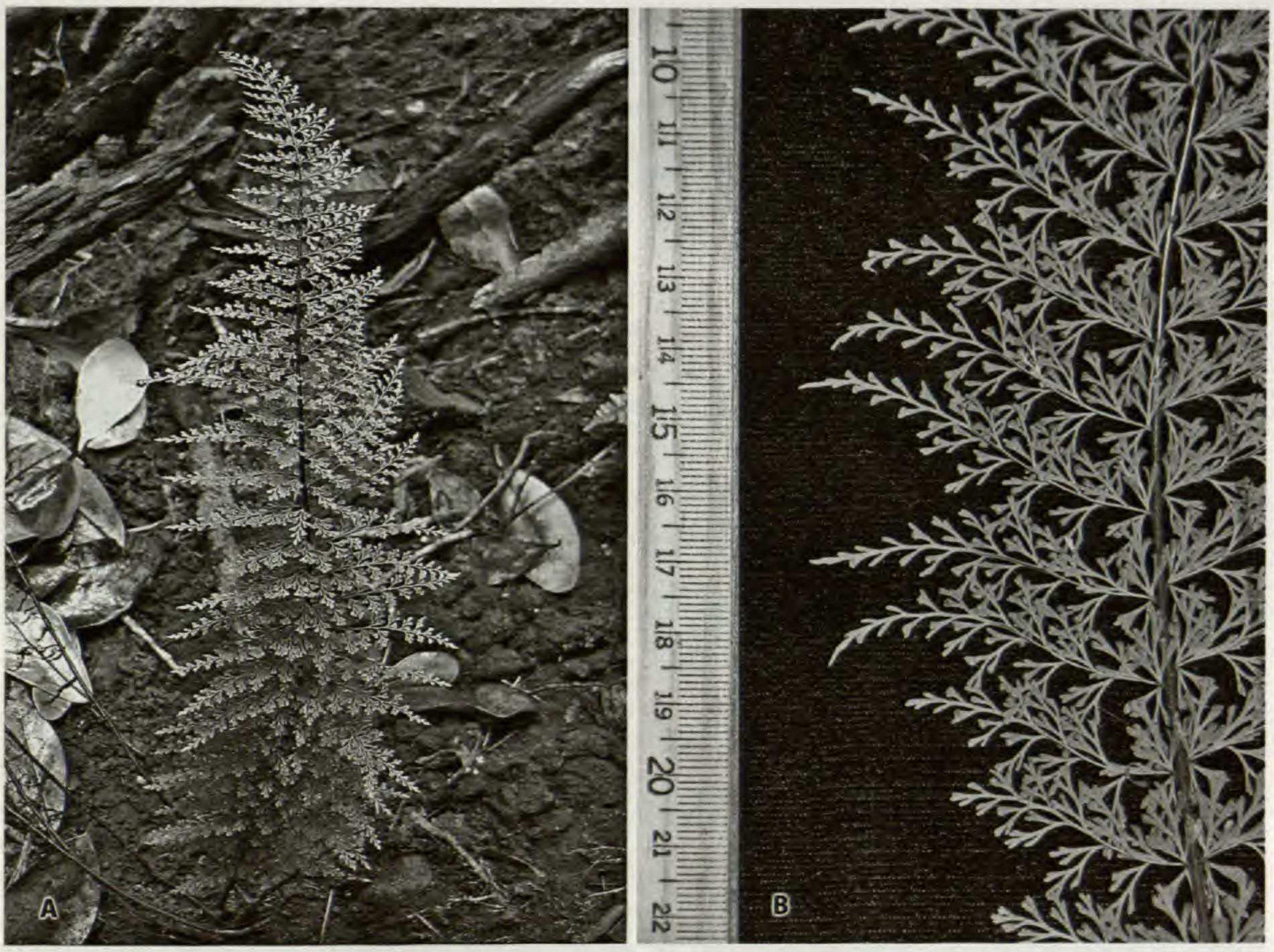

FIG. 3. *Asplenium dielmannii*. A, habit, plant with single frond at Halemanu, Kaua'i; B, detail of frond, Kawai'iki Ridge, Kaua'i. (Photos: A, Ruth Aguraiuja, unvouchered; B, *K. R. Wood 13858*, PTBG.)

Lindsaya alexandri Hillebr. var. *bipinnata* Hillebr., Fl. Hawaiian Isl.: 623 1888. Type: Kaua'i, Halemanu, without precise date, Knudsen s.n. [as "Kn"] (Holotype B, image seen). **Figs. 1, 2.**

Discussion.—The specimen *Knudsen 22* is selected as the lectotype of *Lindsaya knudsenii* because there are two sheets at B consisting of mature, fertile fronds representative of this taxon.

Population status.—Two populations consisting of about 90 reproductive individuals are known in the upper drainage of Kawai'iki Valley, Kaua'i (Aguraiuja, unpublished). Not yet federally listed because of prior taxonomic confusion regarding the nomenclature of this species. However, it is included on the Hawai'i State Plant Extinction Prevention Program (PEP) list http://pepphi.org

2. ***Asplenium dielmannii*** Viane, Biol. Jaarb. 59: 160. 1991, nom. nov. for *Microlepia mannii* D. C. Eaton, Proc. Am. Acad. 7: 212. 1868, not *Asplenium mannii* Hook. (1861). *Diellia mannii* (D. C. Eaton) W. J. Rob., Bull. Torrey Bot. Club 39: 582. 1912. Type: USA, Hawaiian Islands, Kaua'i, Waimea, 2000–3000 ft., *Mann & Brigham 546* (GH, image seen; Isotype US!). **Fig. 3.**

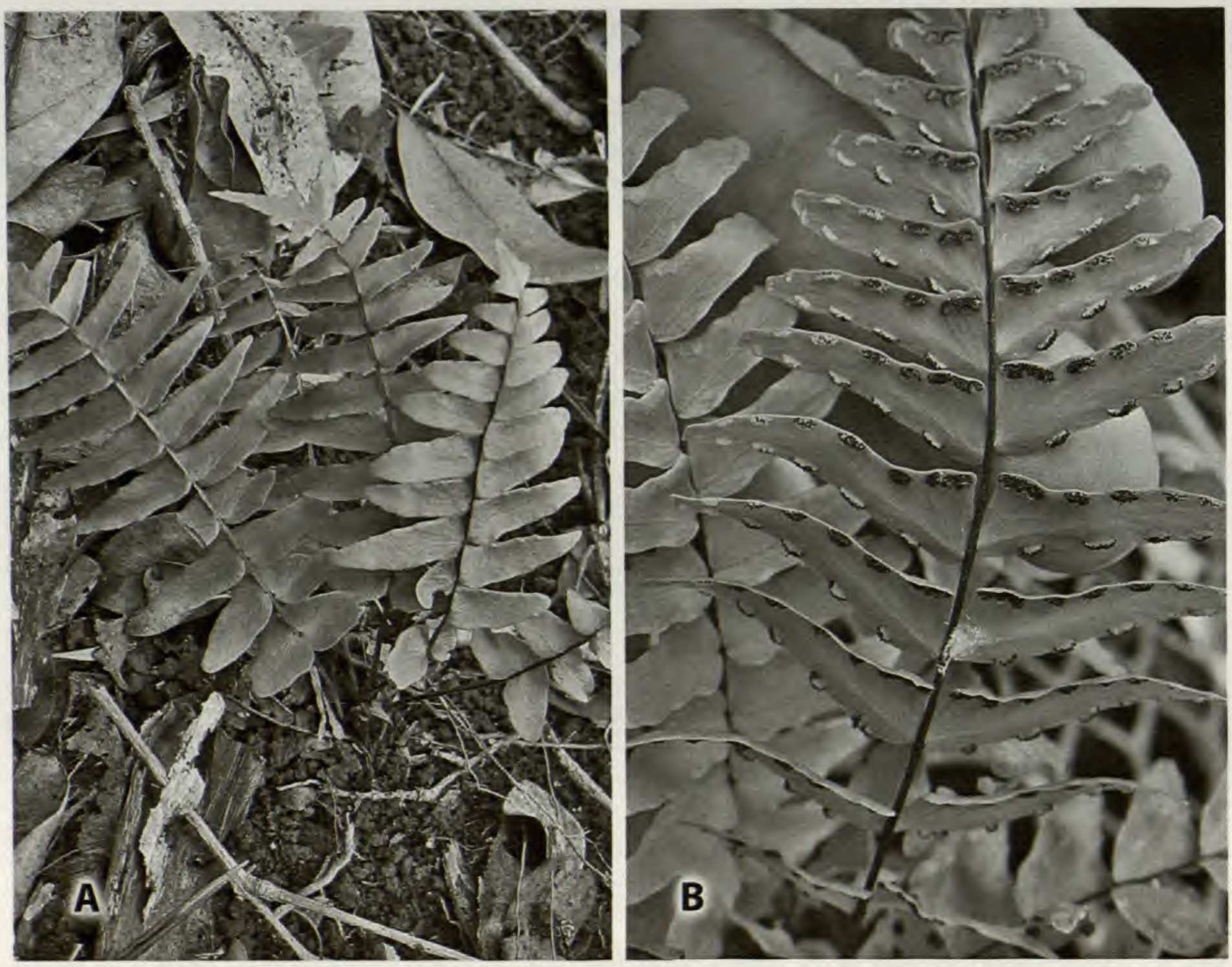

FIG. 4. *Asplenium dielpallidum*. A, habit, plant at Mahanaloa Valley, Kaua'i; B, frond showing mature sori. (Photos: A, Ruth Aguraiuja, unvouchered; B, David Lorence, from cultivated plant NTBG # 070681, origin Mahanaloa Valley, Kaua'i.)

Population status.—This species was formerly considered extinct (Palmer 2003), but was rediscovered on Kaua'i in 2003 (Aguraiuja and Wood, 2003) and is federally listed as endangered. One population consisting of 62 reproductive individuals is known (Aguraiuja, unpublished).

3. ***Asplenium dielpallidum*** N. Snow, Bishop Museum Occasional Papers 110: 12. 2011, nom. nov. for *Diellia pallida* W. H. Wagner, Contr. Univ. Michigan Herb. 19: 66. 1993, not *Asplenium pallidum* Blume (1828). Type: USA. Hawaiian Islands: Kaua'i, Mahanaloa Valley, 10 Aug. 1949, *W. H. Wagner, Jr. 5805* (Holotype MICH 1259996, image seen). **Fig. 4**.

Population status.—Listed as Endangered by the USFWS, the known natural population of this species consists of seven mature individuals in three localities on western Kaua'i (Aguraiuja, unpublished).

Other Hawaiian Species

Other Hawaiian species in the *Diellia* alliance are *Asplenium dielfalcatum* Viane and *A. unisorum* (W. H. Wagner) Viane, both known from O'ahu where

they may hybridize, *A. leucostegioides* Baker from East Maui (presumed extinct), and *Asplenium dielerectum* Viane (all the major islands except Kaua'i, Kaho'olawe and Ni'ihau). Further study is needed to clarify the status of the forms of the Maui Nui plants within *Asplenium dielerectum,* including *Diellia erecta* f. *alexandri* for which the nomenclature and typification are summarized below.

Diellia erecta Brack. f. *alexandri* (Hillebr.) W. H. Wagner, Univ. Calif. Publ. Bot. 26: 155. 1952. Basionym: *Diellia alexandri* (Hillebr.) Diels, Nat. Pflanzenfam. [Engler & Prantl] 1[4]: 212 f. 114 G-K. 1899. *Lindsaya alexandri* Hillebr., Fl. Hawaiian Isl. 622. 1888. Lectotype, designated by Wagner (1952): USA: Hawaiian Islands. Maui: Northern slope of Haleakala, 3000–4000 ft, *Alexander & Lydgate* (Lectotype B, image seen).

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